

## **BLACK LAYER COATED HEAT EXCHANGER**

### **BACKGROUND OF THE INVENTION**

- [1] The present invention relates generally to a heat exchanger for use with the primary heat exchanger of a condensing furnace or the single heat exchanger of a mid-efficiency furnace which includes a layer of oxidized black coating which increases the emissivity of the heat exchanger and allows the heat exchanger to emit more heat.
- [2] A condensing furnace generally includes two heat exchangers, a primary heat exchanger and a condensing heat exchanger. Air and natural gas enter a burner where they are burned to form hot combustion products. The primary heat exchanger cools the hot combustion products, extracting and supplying heat to the air that is to be heated. A standard ("mid-efficiency") furnace generally includes only a single heat exchanger which cools the hot combustion products, extracting and supplying heat to the air to be heated.
- [3] These heat exchangers are commonly formed of a shiny aluminized steel. As the aluminized steel is shiny, the steel does not radiate heat well and has a low emissivity. Emissivity is the ability of a surface to emit heat by radiation. For example, black bodies have a higher emissivity than lighter bodies and are therefore able to emit more heat by radiation than lighter bodies.
- [4] There are several drawbacks to the aluminized steel heat exchanger of the prior art. For one, aluminized steel is expensive. Additionally, as the aluminized steel has a low emissivity, the steel does not radiate heat well.
- [5] Hence, there is a need in the art for a furnace heat exchanger which increases the emissivity of the heat exchanger and allows the heat exchanger to emit more heat.

### **SUMMARY OF THE INVENTION**

- [6] The present invention relates to a furnace heat exchanger for use with the primary heat exchanger of a condensing furnace or the single heat exchanger of a mid-efficiency

furnace which includes a layer of oxidized black coating which increases the emissivity of the heat exchanger and allows the heat exchanger to emit more heat.

[7] A furnace heat exchanger made of steel alloy or metal-coated steel is electrochemically coated with copper metal. An aqueous solution of an oxidizing alkaline inorganic compound oxidizes the copper, producing a black matte layer of cupric oxide (CuO).

[8] As the cupric oxide layer is black, the layer has a high emissivity and emits more heat, increasing the efficiency of the heat exchanger. Also, as cupric oxide has a high decomposition temperature, the cupric oxide is not affected by the flame of the burner which may contact part of the heat exchanger. It is preferable that cupric oxide be coated on both sides of the heat exchanger to further increase efficiency.

[9] Alternatively, the furnace heat exchanger is formed of a steel alloy and is controllably oxidized to form a black coating of magnetite ( $\text{Fe}_3\text{O}_4$ ) which increase the emissivity of the heat exchanger.

[10] Accordingly, the present invention provides a furnace heat exchanger which includes a layer of oxidized black coating which increases the emissivity of the heat exchanger and allows the heat exchanger to emit more heat.

[11] These and other features of the present invention will be best understood from the following specification and drawings.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[12] The various features and advantages of the invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

[13] Figure 1A illustrates a schematic diagram of a condensing furnace system;

[14] Figure 1B illustrates a schematic diagram of a mid-efficiency furnace system;

- [15] Figure 2 illustrates a heat exchanger with a coating of copper electrochemically applied to the surface of the heat exchanger;
- [16] Figure 3 illustrates a heat exchanger with a coating of cupric oxide;
- [17] Figure 4 illustrates a heat exchanger with a coating of cupric oxide on both the inner surface and the outer surface of the heat exchanger; and
- [18] Figure 5 illustrates a heat exchanger with a coating of cupric oxide on the inner surface and a coating a magnetite on the outer surface of the heat exchanger.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

- [19] Figure 1A schematically illustrates a condensing furnace system 10A. Air and natural gas enters a burner 12A which burns the air and natural gas by a flame 11 to produce hot combustion products. The hot combustion products pass through a primary heat exchanger 14A, which cools the hot combustion products and extracts heat to the air to be heated. To increase the efficiency of the system 10A, a condensing heat exchanger 16 is used to extract additional heat. As the hot combustion gases pass through the condensing heat exchanger 16A, the condensing heat exchanger 16A cools the combustion products to a temperature below the dewpoint of the combustion products. Water vapor begins to condense, allowing more heat to be extracted from the combustion products and increasing efficiency. As the liquid condensate condenses, heat is transferred from the water vapor to the air to be heated. An inducer fan 18A provides a source of suction on the condensing heat exchanger 16A and assists in pulling the flow of the combustion products through the system 10A. The combustion products are expelled from the system 10A through a flue 20A.
- [20] Figure 1B schematically illustrates a mid-efficiency furnace system 10B, which works similarly to the condensing furnace system 10A, but does not include a condensing heat exchanger 16A. Heat from the hot combustion products produced by the burner 12B is extracted by the single heat exchanger 14B and supplied to the air to be heated. The

inducer fan 18B provides suction on the combustion products which are expelled through the flue 20B.

[21] As shown in Figure 2, a coating of copper metal 22 is applied to the surface 24 of the heat exchanger 14 to assure adhesion. The heat exchanger 14 is either a primary heat exchanger 14A of a condensing furnace system 10A or a single heat exchanger 14B of a mid-efficiency system 10B. The heat exchanger 14 is made of either a steel alloy or a metal-coated steel. Preferably, the coating of copper metal 22 is electrochemically applied to the surface 24. However, it is to be understood that other suitable methods of attachment are possible, and one skilled in the art would know how to attach the copper metal 22 to the surface 24 of the heat exchanger 14. An aqueous solution of an oxidizing alkaline inorganic compound is applied to the copper coating 22. An aqueous oxidizing alkaline solution contains an excess of hydroxide (OH<sup>-</sup>) ions and an oxidizing compound. The hydroxide ions react with and oxidize the copper coating 22, producing a layer of cupric oxide (CuO) 26, shown in Figure 3. The heat exchanger 14 is either immersed in a bath of the aqueous oxidizing alkaline solution, or the solution is applied as a spray.

[22] The layer of cupric oxide 26 on the heat exchanger 14 is matte black. As black bodies emit more heat, the black cupric oxide coated heat exchanger 14 has a higher emissivity than the shiny aluminized steel heat exchanger of the prior art. Emissivity is the relative power of a surface to emit heat by radiation. As the cupric oxide layer 26 of the heat exchanger 14 is matte black, the heat exchanger 14 has a high emissivity and a greater ability to emit heat.

[23] Additionally, the cupric oxide has a melt or decomposition temperature of 1326°C. The decomposition temperature is the temperature at which the cupric oxide is affected or melted by heat. As the heat exchanger 14 does not reach a temperature of over 650°C, the layer of cupric oxide 26 will not melt or decompose due the heat of the flame 11 of the burner 12 which may contact part of the heat exchanger 14.

[24] As the matte black cupric oxide layer 26 has a high emissivity, the heat exchanger 14 is more efficient. In a furnace where only a heat exchanger 14 is utilized, both the size

of the heat exchanger 14 and the furnace can be reduced, reducing manufacturing costs. Alternatively, if the primary heat exchanger 14 remains the same size, the efficiency of the heat exchanger 14 is increased as there is a lower gas flue exit temperature. As the efficiency of the heat exchanger 14 is increased, the size of the condensing heat exchanger 16 can be reduced. This is advantageous as the material of the condensing heat exchanger 16 is expensive as it must be made resistant to corrosion.

[25] As shown in Figure 4, efficiency can further be increased by coating both the inner surface 28 and the outer surface 30 of the heat exchanger 14 with cupric oxide. By coating both surfaces 28 and 30, the emissivity of the heat exchanger 14 is further increased, allowing for an additional increase in efficiency.

[26] In an alternative embodiment, a heat exchanger 14 formed of a steel alloy is electrochemically coated with iron. The iron is controllably oxidized with an aqueous alkaline solution chemically formulated to form a black coating of magnetite ( $\text{Fe}_3\text{O}_4$ ). It is preferable that magnetite only be utilized on the outer surface 30 of the heat exchanger 14 as heat from the flame of the heat exchanger 14 can oxidize the black magnetite on the inner surface 28 further and turn it red, lowering efficiency. In one embodiment, as shown in Figure 5, a layer of magnetite 32 is utilized on the outer surface 30 of the heat exchanger 14 which is exposed to the environment and a layer of cupric oxide 26 is used on the inner surface 28 of the heat exchanger 14. The layer of magnetite 32 also has a high decomposition temperature and does not decompose or melt due to the heat of the condensing furnace system 10.

[27] There are several advantages to using the black coated heat exchanger 14 of the present invention. For one, the aluminized steel heat exchanger of the prior art is shiny so it does not radiate heat well. As the matte black cupric oxide layer 26 on the heat exchanger 14 has a higher emissivity, the heat exchanger 14 can emit more heat and the efficiency of the heat exchanger 14 is increased. Finally, cupric oxide layer 26 is stable and does not decompose due to the high temperatures the heat exchanger 14 is exposed to.

[28] Accordingly, the present invention provides a heat exchanger for a condensing furnace which includes a layer of an oxidized black coating which increases the emissivity of the heat exchanger and allows the heat exchanger to emit more heat.

[29] The foregoing description is only exemplary of the principles of the invention. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed, however, so that one of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specially described. For that reason the following claims should be studied to determine the true scope and content of this invention.